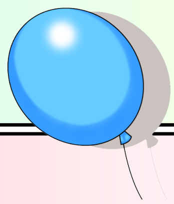
5.1.4 Ideal gases

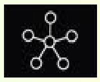
	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	amount of substance in moles; Avogadro constant N_A equals 6.02×10^{23} mol^{-1}	
(b)	model of kinetic theory of gases	assumptions for the model: large number of molecules in random, rapid motion particles (atoms or molecules) occupy negligible volume compared to the volume of gas all collisions are perfectly elastic and the time of the collisions is negligible compared to the time between collisions negligible forces between particles except during collision HSW1
(c)	pressure in terms of this model	HSW1, 2 Explanation of pressure in terms of Newtonian theory.

(6) M - Define the mole using Avogadro's constant
(7) S - Describe the model of kinetic theory of gases and its assumptions.
(8) C - Explain of gas pressure in terms of this model and Newtonian theory.

Lesson 1. The kinetic theory of gases

STARTER: How many gas particles are there in the balloon?





Kilo 10^3

Mega 10^6

Giga 10^9

Justify your estimate using physics

How could you measure it?

Key point

One **mole** is defined as the amount of substance that contains as many particles as there are in 0.012kg of Carbon-12.

Or **Avogadros constant** (6.02×10^{23})

$N = n \times N_A$

$n = ?$

N – Number of particles

n – number of moles

N_A – Avogadros constant

$m = n \times M$

m – mass of gas

n – number of moles.

M – Molar Mass

assume $M = M_{\text{nitrogen}}$.

$n = \frac{m}{M}$

$= \frac{0.26 \times 10^{-3}}{0.028} \overset{*}{=} 0.0104$ moles.

$N = n \times N_A$

$= 0.0104 \times 6.02 \times 10^{23}$

$= 6.235 \times 10^{21}$.

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Lesson 1. The kinetic theory of gases

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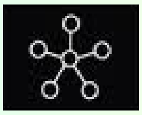
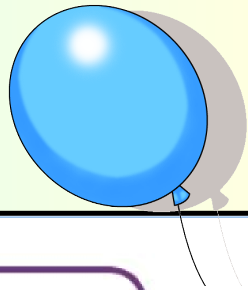
ACTIVITY 3: Read and make notes on molar mass.
Note the equation and the quantities.
Complete Q1-3





Molar mass

The **molar mass**, M, of a substance is the mass of one mole of the substance. Knowing the molar mass allows us to calculate the mass m of a sample of a substance if we know the number of moles, n, and vice versa:

$$m = n \times M$$

1. Calculate the mass of 4.0 mol of helium gas.
2. Calculate the molar mass of methane (CH_4). The molar mass of carbon is 0.012 kg mol^{-1} and the molar mass of hydrogen is 0.001 kg mol^{-1}.
3. Calculate the number of molecules in 50 g of carbon dioxide.

(6) M - Define the mole using Avogadro's constant
(7) S - Describe the model of kinetic theory of gases and its assumptions.
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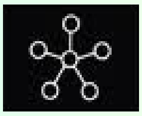
Lesson 1. The kinetic theory of gases

0:00:02

ACTIVITY: Describe the motion of gas molecules in the balloon.

Random direction, Changing direction



constant
V avege = Zero.

Kilo 10^3
Mega 10^6
Giga 10^9

Rotating

How does the motion of the molecules relate to the macroscopic properties of the gas?

force exeted causing Pressure.

Key point

1. Large number of molecules in random, rapid motion.
2. particles occupy negligible volume compared with the volume of the gas.
3. all collisions are perfectly elastic
4. Time of collisions is negligible compared to the time between collisions
5. negligible forces between particles except during collisions → (Electrostatic)

How can you remember all of these?

It what way is a real gas more complex in its behaviour?

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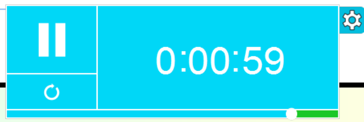
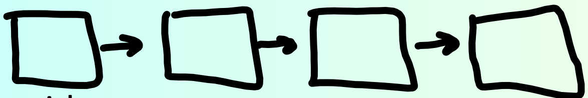
(8) C - Explain of gas pressure in terms of this model and Newtonian theory.

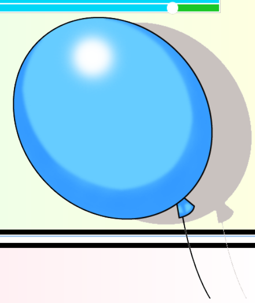
Lesson 1. The kinetic theory of gases



ACTIVITY: Why does a gas cause a pressure on a surface?



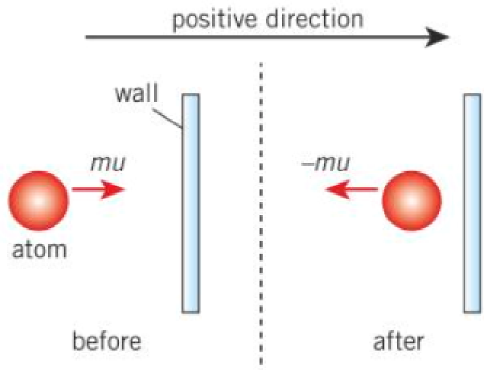
Sequence your ideas.



Kilo 10^3
Mega 10^6
Giga 10^9

Use ideas about the kinetic model AND Newton's laws.

Key point



What is the change in momentum after a collision with the wall?

$-2mv$

$-mv - mv$

$= -2mv.$

1. Molecules in rapid , random motion.
2. Particles collisions with a surface experience a change in momentum = -2mu
3. Using **Newton's 2nd law** - force = rate of change of momentum
4. Using **Newtons 3rd law** the interaction exerts an equal and opposite force on the wall.
5. Many particles exert a resultant force on the wall. This force / surface area = a pressure

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Lesson 1. The kinetic theory of gases

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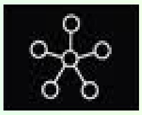
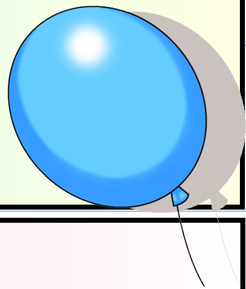
ACTIVITY: Complete the summary questions





Kilo 10^3 Q1-3
Mega 10^6 Q3-5
Giga 10^9 Q4-6

Summary questions

1 Calculate the number of elementary entitles (atoms or molecules) in 3.0 mol of a substance. *(2 marks)*

2 Suggest why one mole of silicon has a different mass from one mole of aluminium. *(2 marks)*

3 A molecule of mass 5.3×10^{-26} kg travelling at 500 m s^{-1} collides with a container wall. It collides at right angles to the wall. Calculate the change in the momentum of this molecule. *(2 marks)*

4 Calculate the number of moles there are in a substance containing:
a 2.0×10^{24} molecules
b 1.5×10^{17} atoms
c 2.0×10^{24} molecules. *(3 marks)*

5 **a** The molar mass of copper is 64 g mol^{-1} calculate the number of atoms in copper of mass 1.0 kg. *(2 marks)*
b The molar mass of uranium is 235 g mol^{-1}. Calculate the mass of a single atom of uranium. *(2 marks)*

6 The density of lead is 11340 kg m^{-3}. Each lead atom has a mass of 3.46×10^{-25} kg. Calculate the number of moles of lead in a lead block with a volume of 0.20 m^3. *(4 marks)*

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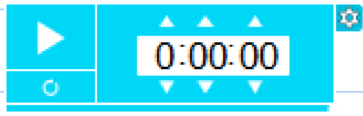
Plenary



$N = n \times N_A$ $\qquad$ $m = n \times M$

Identify each of the quantities and units above.
Define 2 of the terms